California Department of Transportation
Transportation System Information Program

Transportation System Performance Measures
Aviation

Technical Memorandum

Booz·Allen & Hamilton Inc.
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LIST OF EXHIBITS

APPLICABILITY OF PERFORMANCE MEASURES TO AVIATION

1. EXECUTIVE SUMMARY

This technical memorandum responds to the Policy Advisory Committee's recommendations to research the applicability of system performance measures to aviation. Proof-of-concept testing was conducted for seven outcomes and is presented herein. This document contains an executive summary including findings, conclusions, and recommendations. The main body of the report examines the definition for each transportation outcome, relevant data sources, the indicator or indicators, the results of proof-of-concept testing (if appropriate), and recommendations for the seven outcomes examined:

- Mobility / Accessibility
- Reliability
- Safety / Security
- Transportation System Preservation
- Environmental Quality
- Cost Effectiveness
- Economic Well-Being.

In the back of this report is a "Quick Reference Guide" which outlines detailed findings, conclusions and recommendations for each outcome listed above.

Results of the analysis of aviation-related performance measures presented in this report provide meaningful systemic performance information. Compiled on a regular basis, this information will aid planning and decision-making processes and add value to the state's roles in aviation.

The proof-of-concept testing indicates that the proposed indicators can be successfully calculated. There is a recognition that the indicators developed would have different degrees of applicability to monitoring aviation system performance:

- The first set of indicators (i.e., for mobility/accessibility, reliability, safety/security, transportation system preservation, and environmental quality) are immediate applicable for monitoring at a system-wide level

- The second set of indicators (i.e., for cost effectiveness and economic well-being) are applicable but more suitable for use by airports directly or for forecasting.

Where appropriate, the indicators recommended in this report should be integrated into state, regional and local planning documents including the California System Aviation

Plan (CASP) and future transportation trends in California reports. Additional research is proposed to link aviation-related air emissions with regional air quality attainment status and emissions budgets.

2. AVIATION PERFORMANCE MEASURES: FINDINGS BY OUTCOME

2.1 Introduction

Aviation consists of commercial aviation (cargo and passengers) and general aviation (i.e., other air travel such as recreational and privately owned planes).

Many institutional players have regulatory or commercial interests in the performance of California's aviation system:

- Federal Aviation Administration (FAA)
- Regional groups (e.g., Regional Transportation Planning Agencies, Metropolitan Planning Organizations, Air Districts)
- Airlines
- Industry groups (e.g., Air Transport Association, Airports Council International, National Air Transportation Association)
- State (i.e., California Department of Transportation)
- Airports
- Local governments and land use agencies (e.g., counties, cities).

Proof-of-concept testing regarding the applicability of performance measures to aviation was conducted from October 2000 to July 2001 under the direction of Caltrans' Policy Advisory Committee. The seven transportation outcomes examined included: mobility/accessibility; reliability; safety/security; transportation system preservation; environmental quality; cost effectiveness; and economic well-being.

The research referred to in this report was conducted for the Performance Measures Initiative by staff from Booz·*Allen and Caltrans' Office of Performance Measures and* Data Analysis. Many data sources were relied on for the research including the Federal Aviation Administration (FAA), California airports, the U.S. Environmental Protection Agency (EPA), the California Air Resources Board (CARB), and individual Air Quality Management Districts (AQMDs). A wide variety of U.S. Department of Transportation databases were investigated. Interviews were conducted with representatives from the afore-mentioned agencies as well as with individuals representing California airports. Numerous government documents were reviewed and proof-of concept testing was conducted in order to provide recommendations for appropriate indicators and their interpretation.

This document is divided into separate sections for the seven performance outcomes. Each section consists of a brief introduction, data sources, indicator(s), results of proof-of-concept testing with examples where appropriate, and a short explanation of how results might be interpreted to add value to decision-making processes. In addition, at the end of the presentation on each outcome, a "where are we headed now" paragraph describes next steps related to the outcome.

2.2. Mobility / Accessibility

The two components of this outcome are mobility and accessibility. Each component is addressed one at a time in the pages that follow.

2.2.1 Definition for Mobility

Mobility is defined as reaching desired destinations with relative ease within a reasonable time, at a reasonable cost, with reasonable choices.[1]

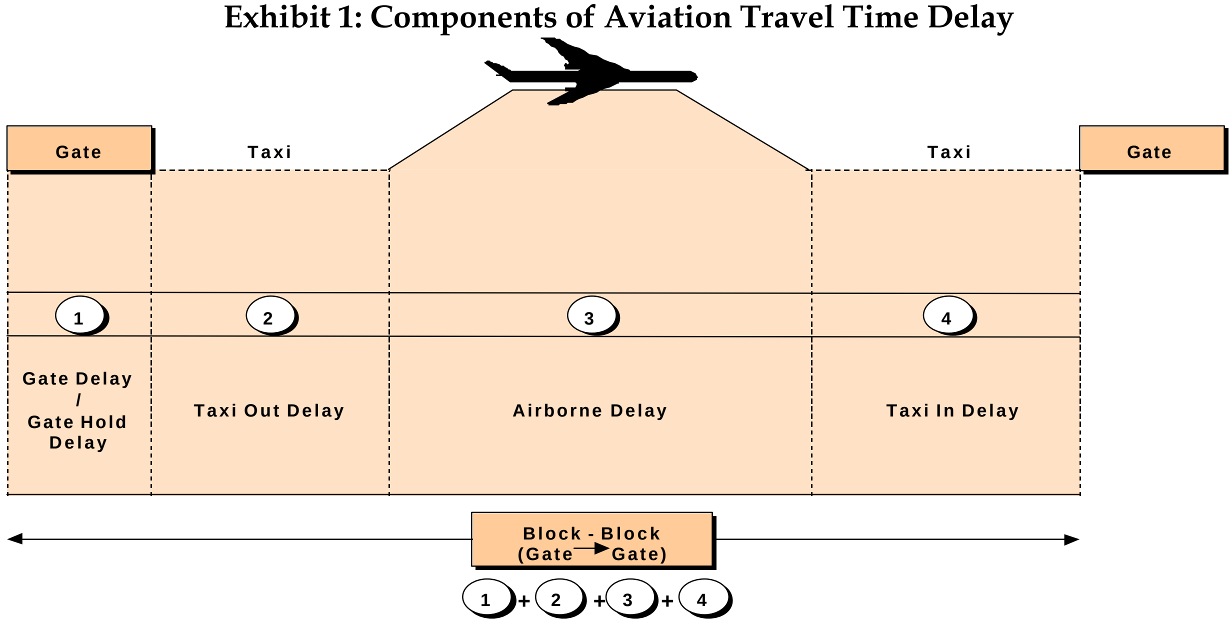
2.2.2 Indicator

The proposed indicator for aviation-related mobility is travel time delay, which represents the difference between the scheduled and the actual flight times. This indicator is consistent with the mobility indicators for other modes considered by the System Performance Measures Initiative.

One important point to note when interpreting delay data is that in the past efforts by private airlines to minimize the appearance of delay have resulted in altered "schedule" times. This gives the appearance that an airline's "on-time" performance is improving even in the face of increasing travel times. Such schedule changes can be addressed through ongoing monitoring of scheduled times for specific trips.

Total travel time delay, or block time, can be divided into four components: gate delay/gate hold delay, taxi out delay, airborne delay, and taxi in delay as shown in Exhibit 1.

Exhibit 1: Components of Aviation Travel Time Delay



[1] *California Transportation Plan Transportation System Performance Measures Final Report, 1998*

2.2.3 Data Sources

In order to quantify travel delay by block element for California airports and origin-destination (O-D) pairs, several data sources were reviewed in detail:

- Consolidated Operations and Delay Analysis System (CODAS)
- Air Travel Consumer Report (ATCR)
- Air Traffic Operations Management System (ATOMS)
- Airline Service Quality Performance System (ASQP)
- Operations Network (OPSNET)
- Official Airline Guide (OAG).

Of these, CODAS, from the FAA, is the most appropriate source. It incorporates information from commercial operations in California, contains data that is readily available through the FAA's Aviation Policy and Plans (APO) Data System website and is available at no cost.

2.2.4 Proof-of-Concept

Using CODAS, proof-of-concept testing was conducted for the top Origin-Destination (O-D) pairs and for the top California airports. Results for the top O-D pairs, ranked by the number of flights, are illustrated below in Exhibit 2.

Exhibit 2: Sample Delay For The Top O-D Pairs In California - 1999

Departures	Arrivals	Total Flights	Total Gate Delay in Minutes	Taxi Out Delay in Minutes	Airborne Delay in Minutes	Taxi In Delay in Minutes	Total Delay/ Flight in Minutes	Total Delay/ Year in Hours
SAN	LAX	24160	9.08	1.51	0.33	1.51	12.43	5,005.15
LAX	SAN	24047	7.69	3.74	0.44	0.07	11.94	4,785.35
LAX	SFO	17581	15.05	5.38	2.65	0.82	23.90	7,003.10
SFO	LAX	17326	12.03	4.37	3.95	3.75	24.10	6,959.28
LAX	OAK	11402	7.59	4.27	0.85	0.73	13.44	2,554.05
OAK	LAX	11296	9.07	2.78	4.11	3.31	19.27	3,627.90

Source: CODAS database from FAA and Booz·Allen & Hamilton Analysis

The above table contains a sample of delay data presented by delay component. In addition to calculating delay for individual O-D pairs, it is also possible to use CODAS to calculate delay for the top commercial airports in California. The combination of O-D pair and individual airport data allows a more comprehensive analysis of delay for major commercial operations in California.

2.2.5 Interpretation of Performance Measure

Year-to-year monitoring of aviation-related delay allows decision-makers to track delay trends:

- identifying which components of delay have increased
- tracking which O-D pairs have the most delay year-to-year
- monitoring which airports have the most delay year-to-year.

Monitoring of delay data can provide valuable insight and would provide information to improve decision making related to airport operations and expansions. Time monitoring of delay data allows decision makers to more closely focus their attention and efforts on the portions of trips where delay occurs. If total delay increases, decision makers may advocate changes in operations for the trip components that experience the most delay. Aviation impacts businesses, commuters, tourism, and goods movement in California. Construction of new airports, directing certain trip types to less congested airports, or concentrated efforts on developing or expanding alternative modes of transportation are all possible strategies to relieve delay.

2.2.6 Where Are We Headed Now?

It is recommended that the mobility indicator be adopted. It is recommended that the mobility indicator be calculated for the top twenty O-D pairs and the top ten airports in California (determined by the total number of flights).

2.2.7 Definition for Accessibility

Accessibility is defined as reaching desired destinations with relative ease within a reasonable time, at a reasonable cost with reasonable choices.[2]

2.2.8 Indicators

The proposed indicators for aviation-related accessibility are distance or travel time to the aviation system (i.e., individual airports), distance or travel time to aviation service (i.e., international, interregional, commuter airports) and the number and quality of surface modes used to get to and from airports. Aviation system accessibility can be measured similarly as accessibility to transit and highways and is defined as the percent of the local population (or market) residing within a specified distance or travel time from the aviation system.

2.2.9 Data Sources

Distance or travel time-based buffer analysis is possible through a combination of census and aviation market data. Both approaches involve the use of Geographic Information System (GIS) coverages to determine the percentage of the population that has access (measured in either distance or time) to airports. The source for access to desired modes at airports are the airports themselves.

2.2.10 Proof-of-Concept

Accessibility to the aviation system can be measured by distance or travel time-based buffer analysis to all airports (e.g., the entire aviation system) or specified types of air service (international, commuter, interregional, goods movement, etc.). Through combined use of GIS and census data, sample ring maps were produced for testing. The result of testing was that accessibility, measured by the percentage of the local population living within a specified distance from an airport, could be determined.

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[2] *California Transportation Plan Transportation System Performance Measures Final Report, 1998*

Testing for time-based accessibility was not completed due to lack of data. This issue requires further research.

A second indicator, used to measure the accessibility of airports by surface transportation modes, was also tested. Results of testing indicate that data is available from airport surveys, but that the listing of surface modes connecting to airports alone is not fully adequate to gauge surface mode accessibility. What is missing in the evaluated data is a qualitative and quantitative element of accessibility relating directly to the surface mode service provided (e.g., bus and rail service headways). The table below is used to illustrate the measurement of basic accessibility to surface modes at large, commercial airports in California.

Exhibit 3: Accessibility To Surface Transportation Modes at California Airports

Airport	Private Vehicle	Scheduled Bus Service (private)	Regional Bus Transit	Valet Shuttle	Taxis & Limousines	Other	Employee Shuttle	Remote Park & Ride	Park & Ride (private)	Rental Car Shuttle	Rail Service
Large Commercial Airports											
Burbank-Glendale - Pasadena	x	-	x	x	x	-	x	-	-	x	x
John Wayne Airport - Orange County	x	x	x	x	x	-	-	-	-	x	-
Los Angeles International	x	x	x	x	x	-	x	x	-	x	x
Metropolitan Oakland International	x	x	x	x	x	Air BART	x	x	-	x	x
Ontario International	x	x	x	x	x	Terminal Connection Shuttles	-	x	-	x	-
Sacramento International	x	-	x	x	x	Inter-Terminal Bus	-	-	-	x	-
San Diego International	x	-	x	x	x		x	x	-	x	-
San Francisco International	x	x	x	x	x		x	-	x	x	-
San Jose International	x	x	x	x	x	-	x	-	x	-	-

Source: Airport data, 2000

2.2.10 Interpretation of Performance Measure

The first accessibility performance measure indicates the percentage of the population with access to air service. At this time, no criteria have been established regarding desired or optimal percentages. Monitoring the accessibility of air service over time can aid in decision-making on the effects of expanding existing airports, siting new airports or scheduling new air service.

The second accessibility performance measure indicates the number of surface modes serving California airports. An increase in the measure over time reflects an increase in the quantity and/or quality of airport ground transportation options available to the traveling public. Results of monitoring these trends can also aid decision-making. The impact of increasing airport traffic (more flights) or airport capacity (expanding airports) on surface transportation (especially nearby roadways) can be evaluated. Improving ground access provisions at some airports could make the airports more convenient to reach, thus helping relieve congestion at other (competing) airports.

2.2.11 Where Are We Headed Now?

It is recommended that the accessibility indicators be adopted. Continued research is recommended to continue exploring time-based travel accessibility, which will lead to a more accurate measurement of aviation-related accessibility.

2.3 Reliability

This section addresses the reliability outcome, focusing on the reliability of aviation travel.

2.3.1 Definition

The reliability outcome is defined as the level of variability in transportation service between anticipated (based on scheduled or normal travel time) and actual travel.[3]

2.3.2 Indicator

The indicator for aviation-related reliability is variation in travel times for all flights to or from specific airports or between specific O-D pairs. The indicator can be calculated by dividing the standard deviation in travel time by the average travel time.

2.3.3 Data Sources

The U.S. DOT's Bureau of Transportation Statistics' database, ASQP, provides the data necessary to measure aviation system reliability (cost: $1,800/year). The database contains scheduled time, Computer Reservation System time, and actual time. For individual flights, actual versus schedule times are available on a monthly and yearly basis. The indicator calculations can be performed using the raw data obtained from the ASQP database.

2.3.4 Proof-of-Concept

Due to data cost, proof-of-concept testing was not conducted for reliability. However the reliability indicator can be quickly calculated once access to the database is purchased. First, the analyst will gather data for all flights to and from the top O-D pairs in California and the top California airports. Scheduled and actual flight times will then be compared. The standard deviation of travel time divided by the average travel time will yield the "variance", which is the indicator for reliability.

2.3.5 Interpretation of Performance Measure

Air service reliability is critical to California's economy, especially in the area of goods movement. Monitoring of aviation reliability can also assist decisions about connecting surface modes with airports, siting new airports, and expanding existing airports. An increase in this measure indicates that air travel is becoming more reliable, thus users can more accurately estimate trip time. Accuracy in estimating trip time leads to a more efficient use of airport and ground transportation facilities and users' time. A decrease in this measure indicates that further investigation is necessary to determine the reasons

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[3] *California Transportation Plan Transportation System Performance Measures Final Report, 1998*

for the trend. Changes in reliability may be due to weather, increased traffic, or other factors. As a result, decision makers could advocate improvements in airline scheduling or technical devices such as weather forecasting or air traffic control systems.

2.3.6 Where Are We Headed Now?

It is recommended that the ASQP database be purchased from BTS. The data will enable calculation of reliability for the top O-D pairs and for the top airports in California. This will also ensure comparability with mobility results.

2.4 Safety / Security

This outcome is composed of two components: safety and security.

2.4.1 Definition for Safety

Safety is defined as minimizing the risk of death, injury, or property loss.[4]

2.4.2 Indicators

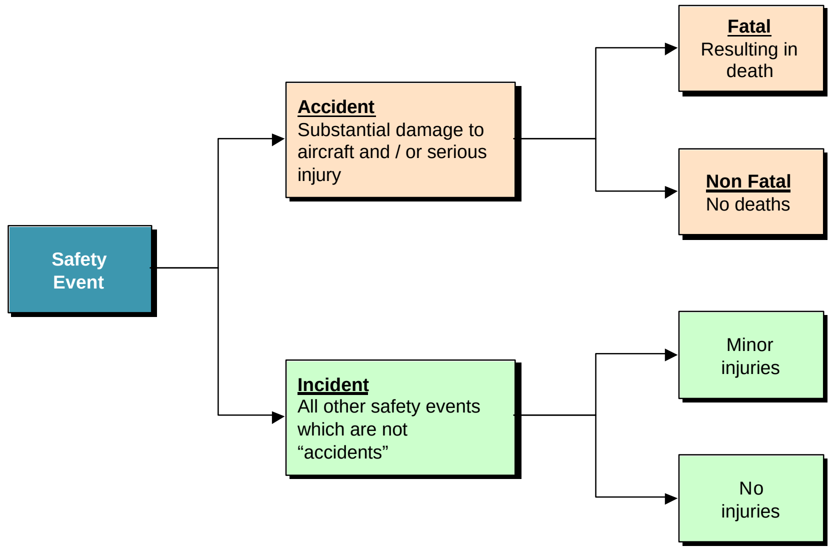
The proposed indicators for aviation-related safety are similar to those applied to surface modes: total accident rate (fatal and non-fatal accidents per vehicle-miles traveled or VMT), fatality accident rate (fatalities per VMT), non-fatal accident rate (non-fatal accidents per VMT), and incident rate (incidents per VMT). There are three main differences in the manner in which safety rate is calculated for aviation versus other modes. First, VMT is defined as O-D pair distance multiplied by the total number of operations between the pairs over a specified time. Second, the National Transportation Safety Board (NTSB) defines "California" accidents and incidents as those occurring within the boundaries of the state of California, without respect to flight origin or destination. Third, the categories of "accident" and "incident" are NTSB designations further detailed below.

2.4.3 Data Sources

Aviation-related safety information is readily available from the NTSB through its searchable database. The NTSB categorizes safety events as shown in Exhibit 4.

[4] *California Transportation Plan, Transportation System Performance Measures Final Report, 1998*

Exhibit 4: NTSB Safety Events



Source: http://www.ntsb.gov/

The graphic above outlines that both incidents and accidents can have associated injuries, but fatalities always fall within the accident category. The implications for the indicator are that both accident and incident rates must be included to adequately represent safety statistics.

2.4.4 Proof-of-Concept

Using the NTSB classification, proof-of-concept testing for safety events was conducted using data from the 1999-reporting year. For major commercial carriers, VMT was calculated by multiplying flight distance by total number of operations for each specific O-D pair market where accidents or incidents occurred. VMT is calculable for large, medium, small, and non-hub commercial airport O-D pairs, as were the corresponding accident and incident rates. The proof-of-concept testing was conducted for total operations. It is also possible to calculate safety events on a per million operations basis.

For general aviation, safety events occurring in 1999 were calculated on a per million operations basis. VMT data was not available for each O-D pair and flight distance related to each of the events.

2.4.5 Interpretation of Performance Measure

Trend analysis of the safety indicator (coupled with an understanding of why the rate is increasing) will allow decision makers to become aware of existing safety rates and potential safety concerns. Safety concerns that may require action by decision makers include: close inspection of ground hazards, adoption of stricter standards in equipment design or operation, changes in FAA tower operations, flight scheduling, pilot testing, passenger conduct, and land uses adjacent to airports.

2.4.6 Where Are We Headed Now?

It is recommended that the safety indicators for aviation be adopted. Data (number of events and associated safety rates) should be collected and managed for commercial airports in California.

2.4.7 Definition for Security

Aviation security has the same definition as aviation safety (it is the same transportation outcome): minimizing risk of death, injury, or property loss.[5] Security refers to incidents involving passengers or airport employees who are the victims of Category 1 or Category 2 crimes.

2.4.8 Indicators

The indicator for security is the security rate for the specific mode, where security rate is further specified as either a "Category 1" or "Category 2" crime.

Category 1 crimes are defined by the Federal Bureau of Investigation (FBI) as: murder, forcible rape, armed robbery, strong-arm robbery, aggravated assault, residential burglary, school burglary, commercial burglary, grand theft, patrollable auto theft, other auto theft, other sex felony, narcotics felony, and all other felonies.

Category 2 crimes are defined by the FBI as: simple assault, petty theft, bike theft, car clout, sex misdemeanor, narcotics misdemeanor, disturbing the peace, malicious mischief, all other misdemeanors.

The security rate for aviation is calculated as category crimes divided by million annual passengers (MAP). That is slightly different from the security rate for surface modes which is calculated as the number of incidents divided by the number of vehicle miles traveled (VMT).

Note that this report was largely written before September 11, 2001. The crime of carrying of weapons through security would be defined as a Category 1 crime (under "all other felonies"). If the crime occurred on-board an airplane, it would be classified as a federal offense. As security policies and procedures continue to change, the information in this section should be periodically updated.

2.4.9 Data Sources

Individual airports are the data sources for security statistics. The U.S. and California Departments of Justice compile California-wide crime statistics, but do not separately categorize airport-related crime statistics. Private security/airport police or port authority police serve major California airports, while smaller airports are frequently provided service by local police forces.

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[5] *California Transportation Plan Transportation System Performance Measures Final Report, 1998*

2.4.10 Proof-of-Concept
Data from the San Jose International Airport was used for proof-of-concept testing. Security rates were calculated by dividing the annual number of security events occurring in or near the airport by the annual number of passengers (in millions) arriving at or departing from the airport during the 1999 reporting year. A security rate for Category 1 and Category 2 crimes was calculated and presented as the rate per million annual passengers.[6]

2.4.11 Interpretation of Performance Measure
An increase in security incident rates over time can be interpreted in different ways. An increase may indicate the need for a reallocation of resources by the airport authority or local police agency. Results may also indicate that one or another specific type of crime is more often being committed and therefore efforts aimed at reducing that specific type of crime might be implemented. However, an increase in the rate can also mean that the airport has tightened security and is actually doing a better job stopping potential crime which would otherwise go undetected/unreported. It could also mean that standards for security have increased. The key is to ensure the safety of passengers and their belongings throughout their entire air experience by understanding how the security rate is derived.

2.4.12 Where Are We Headed Now?
It is recommended that security indicators for aviation be adopted. Crime data should be collected and managed for commercial airports in California.

2.5 Transportation System Preservation

This section examines the transportation system preservation outcome, and how to evaluate the condition of the aviation system infrastructure.

2.5.1 Definition
Transportation system preservation is defined as maintaining the physical assets of the transportation system at a specified or agreed-upon level. For aviation, the critical assets to be preserved are runways and taxiways.

2.5.2 Indicator
Asset condition is the indicator proposed to assess the condition of existing system assets and to reflect changes in the condition of the assets over time. The focus of aviation preservation is the condition of airport pavement. Asset condition is consistent with system preservation measurement in other modes. Condition of airport assets beyond runway and taxiway pavement is extremely difficult to measure since no method is readily available to Caltrans to determine the condition of terminals and other aviation assets. This equipment is either owned privately by the airlines or by individual airports.

[6] *www.sjc.org and San Jose Airport Crime Statistics and BAH analysis*

2.5.3 Data Sources

The data source for asset condition is the Airport Pavement Management System (APMS), a PC-based software maintained by the Caltrans Division of Aeronautics. The existing APMS includes 1994-95 data on 164 airports (out of 266 total statewide). A new system in development will include over 200 airports with updated data. The current and future APMSs do not include any other assets beyond airfield pavement. Data is obtained for each airport by a visual pavement condition survey using standard guidelines established by the FAA. In addition to tracking asset condition, the APMS generates estimated costs for current repair needs, as well as five-year investment requirements if the repairs are deferred.

A subset of APMS is MicroPAVER, a PC-based asset management system software that performs condition analysis, predicts condition, and provides a work plan. Inputs into MicroPAVER include observations of pavement distress type, extent, and severity. Calculation of the Pavement Condition Index (PCI) is then made. The PCI is an average numerical value ranging from 0 (totally failed pavement) to 100 (new pavement) for a pavement sample unit, section or branch. The PCI represents the asset condition for airfield pavement.

2.5.4 Proof-of-Concept

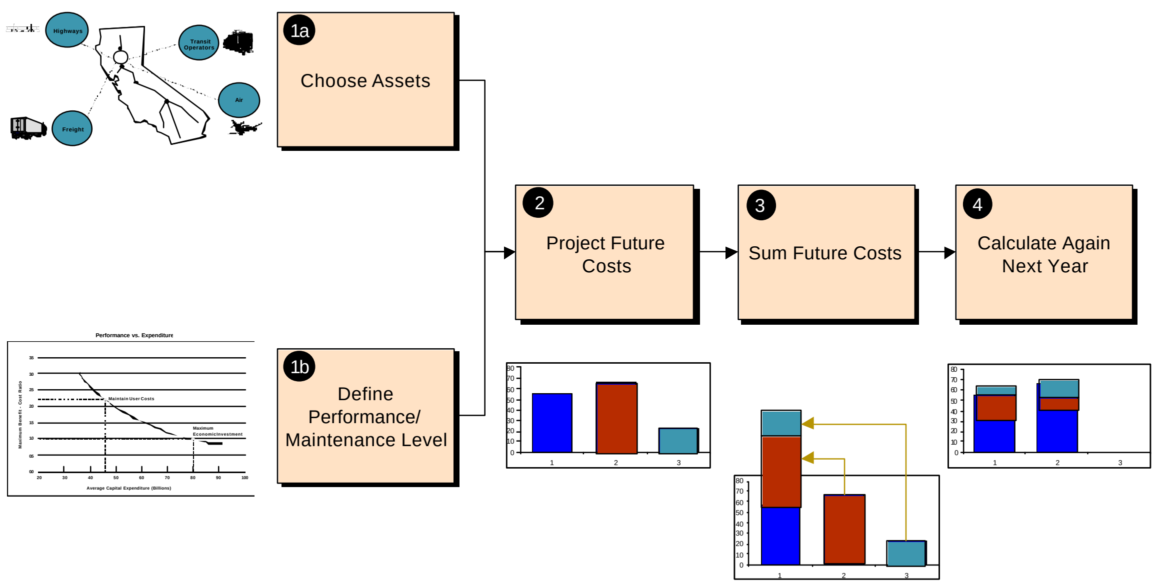
The APMS currently used by Caltrans is the most appropriate source for data relating to the condition of airport runways and taxiways in California. Once the asset condition is determined, results can serve as a basis for deciding preservation strategies.

Two modally blind decision-making strategies, the cost to achieve desired condition and the Preservation Index, were evaluated in the proof-of-concept testing. Both use an assessment of current asset condition as basis for projecting future costs. The cost to achieve desired condition presents the cost in dollars of preserving the transportation system to a desired performance level. The Preservation Index presents the cost to achieve desired condition as an index to more clearly show how the cost to maintain the system at a desired condition changes over time and to consider modally blind expenditure strategies.

Proof-of-concept testing for the cost to achieve the desired condition and the Preservation Index was conducted for transit assets in California using the Federal Transit Administration's Transit Economic Requirements Model (TERM). TERM is used to evaluate the economic return on transit capital investments. It is used to estimate the total annual capital expenditures required to maintain or to improve both the physical condition of transit infrastructure and the level of service transit provides. The model prioritizes transit preservation investments using benefit/cost ratios. Total benefits associated with each investment type are modeled on a transit passenger-mile or vehicle-mile traveled basis.

Exhibit 5 and the following analysis are provided to explain the necessary steps in combining asset condition with the two decision-making strategies.

Exhibit 5: Process for Determining Aviation System Asset Preservation Strategies



As illustrated in Exhibit 5, there are four required steps in calculating the cost to achieve the desired condition and the Preservation Index. The first is to select the assets to be included in the analysis (i.e., runway and taxiway pavement) and to define the performance level (i.e., where the process ends for determining asset condition). The second step is to project future costs associated with preserving the system to a given performance level. The decision-making strategies could employ asset management systems such as the Airport Pavement Management System (APMS) already in use by Caltrans. Using a specified performance level (e.g., maintain conditions), the cost of preserving the system over a designated time horizon (e.g. 20 years) is projected. The third step requires the projected future costs to be summed to generate an estimate of the cost of preserving the entire system. The sum of the cost of preserving each asset equals the total cost of preserving the entire transportation system. This is the cost to achieve the desired condition. In the final step, the total cost of preserving the transportation system as calculated in the previous step is expressed as a Preservation Index. Calculating the cost to achieve the desired condition each year (or every two years) and expressing it as an index shows how the cost to preserve the system changes over time.

It is important to note that consistency in terminology and measurement is extremely important. Consistency in the definition of asset condition or performance level, the use of constant dollars, and the system definition should be maintained over time in order to ensure consistency in interpreting indicator results.

2.5.5 Interpretation of Performance Measure

Trend analysis of the asset condition indicator will allow decision-makers to monitor the condition of aviation's most critical asset, airfield pavement, over time and allocate resources in areas where asset conditions fall below desired levels. Decision makers may also choose to develop a benchmark and allocate resources in such a manner that the desired goal condition is reached or maintained over time.

The remaining two strategies, cost to achieve desired condition and the related Preservation Index, provide insight through monitoring, in absolute dollar terms or as an index, into the cost of maintaining runways and taxiways at a specific level into the future. While both provide decision makers with a scale of asset condition and the costs required to achieve a specified condition, the second is presented as an index and therefore may be easier to compare over time. Again, the key here is assigning values to perceived benefits.

2.5.6 Where Are We Headed Now?

It is recommended that the asset condition indicator be adopted. The indicator should be calculated for all airports that Caltrans monitors. It is also recommended that additional research be conducted on the two additional strategies, specifically for aviation: the cost to achieve desired condition and the Preservation Index.

2.6 Environmental Quality

In this section, the definition and proposed indicators of environmental quality are described. Air and noise emissions around airports can significantly impact surrounding residences or businesses and are thus important to monitor over time.

2.6.1 Definition

Environmental quality is defined as helping to maintain or enhance the natural and human environment[7]. Airport-related environmental impacts primarily relate to noise and air quality.

2.6.2 Indicator

The proposed indicator for the impact of airport-related noise on areas near airports is Community Noise Equivalent Levels (CNEL).

The proposed indicator for air quality at airports is air emissions at airports. However, air emissions data are not presently available for California airports. No individual agency monitors airport air emissions regularly. In the case of major expansions, air emissions for airports are forecast but no post-construction evaluations are conducted.

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7 *California Transportation Plan: Transportation System Performance Measures Final Report, 1998*

2.6.3 Data Sources

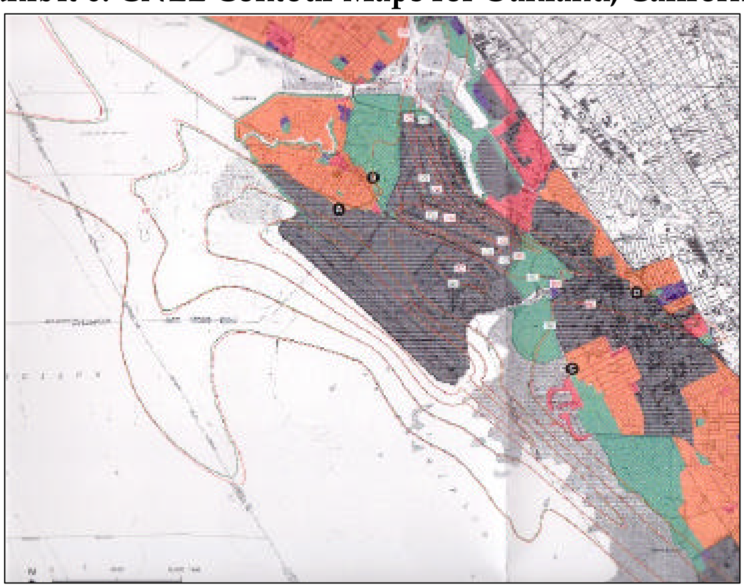
The main sources for aviation-related noise impact data are regional or county noise-quality management districts and individual airports. The main sources for air quality data are the Federal Environmental Protection Agency (EPA); the California EPA - Air Resources Board (CARB); the FAA; regional or county air quality management districts; and individual airports. However, airport-specific emission statistics are not available for California airports. In summary, noise-related data are readily available from a variety of sources, while air-related emissions data are not available at the present time.

2.6.4 Proof-of-Concept

State of California officials use the 65 decibel (dB) Community Noise Equivalent Level (CNEL) contour to define an airport noise impact area. The 65 dB CNEL contour is a computed measure of the day and night average annual decibel level in a given area. Different land uses are judged to be compatible or incompatible with respect to a given contour. For example, residences (considered an incompatible land use) within a 65db contour are often eligible for noise abatement programs provided by local airport districts, while businesses (considered a compatible land use) within the same area are not eligible.

The following is an example of a CNEL contour map for the Metropolitan Oakland International Airport.

Exhibit 6: CNEL Contour Maps for Oakland, California



Source: Final EIS for Oakland International Airport, Airport development program, December 2000

This map reveals specific land-use designations used by each jurisdiction and delineates noise contours within the designated land uses. Different colored CNEL contours represent different noise levels. Individual airports maintain noise-related abatement data.

Given the lack of data, proof-of-concept testing for airport-related air quality indicate that further research is necessary to determine the sources and procedures used to determine aviation's impact on air quality.

2.6.5 Interpretation of Performance Measure

The first proposed environmental quality indicator relates to the impact of airport noise on communities near airports (CNEL). Communities include private residences, businesses, and public facilities (e.g., parks). There is a recognition that certain types of land use (e.g., residences) are considered more impacted by noise than others, which in turn influences funding through noise abatement programs.

One way to track success in noise abatement programs is by tracking abated homes (either the total number or as a ratio). Monitoring of abated homes would allow decision makers to ensure that noise abatement programs make progress in eliminating the negative environmental impact of airport-related noise.

The second proposed environmental performance measure relates to the impact of airport emissions on regional air quality. When completed, the measure will indicate the airports where reductions of air emissions in non-attainment areas may be necessary, thereby assisting decision makers.

2.6.6 Where Are We Headed Now?

It is recommended that the indicator for noise be adopted. Additional research is recommended to link aviation-related air emissions with regional air quality status and emissions budgets. If appropriate data is located, it is recommended that the measure be considered for adoption.

The next set of indicators - cost effectiveness and economic well-being - are applicable to aviation but more suitable for use by airports directly or for forecasting.

2.7.1 Cost Effectiveness

This outcome focuses on the effectiveness of aviation-related investments. Cost-effectiveness is measured as a ratio between benefit and cost.

2.7.2 Definition

Cost effectiveness is defined as the benefits realized from transportation compared to the cost of providing the transportation services.[8]

2.7.3 Indicator

The proposed indicator for cost effectiveness is the benefit/cost ratio. In previously conducted proof-of-concept testing for surface modes, several indicators such as

8 *California Transportation Plan Transportation System Performance Measures Final Report, 1998*

benefit/cost ratio, net present value, internal rate of return, and cost effectiveness ratio were tested. The FAA has used the benefit/cost ratio indicator to estimate and evaluate the value of aviation projects extensively.

2.7.4 Data Sources

The FAA provides several frameworks for conducting benefit/cost analyses. The quantification of costs and benefits relating to investments and projects is provided by the individual airports.

2.7.5 Proof-of-Concept

The FAA has established guidelines for airport sponsors applying to receive federal funds.[9] Although proof-of-concept testing was not conducted for specific projects, the FAA guidelines for benefit/cost analysis are comparable to previously conducted benefit/cost proof-of-concept testing for surface modes. Both methods delineate similar benefit categories of travel time, safety, operating costs, and environmental quality. Other considerations for conducting benefit/cost analysis, such as discount rate and life cycle, vary slightly.

2.7.6 Interpretation of Performance Measure

The proposed indicator, benefit/cost ratio, allows decision makers to choose aviation projects based on the relative ratios between project benefits and costs. The method of quantification of benefits and costs has a significant impact on the indicator (i.e., categories of benefits included, and assignment of dollar value). Once the quantification methodology is selected, the indicator can be calculated, and potential aviation-related projects (e.g., paving projects) can be compared. Those with the highest benefit/cost ratios can be identified as such.

2.7.7 Where Are We Headed Now?

It is recommended that further research into how cost-effectiveness can be applied to appropriate aviation strategies continue. There is a recognition that cost effectiveness may be more appropriate for airports to evaluate the merits of projects. It is yet to be determined how cost-effectiveness can be applied to region-wide, or statewide bundles of projects.

2.8 Economic Well-Being

The last outcome included in the proof-of-concept testing for aviation was economic well-being.

9 *http://www.faa.gov/arp/bca.htm*

2.8.1 Definition

The economic well-being outcome is defined as the contribution to California's economic growth.[10]

2.8.2 Indicators

The factors used to create performance measures for the economic well-being of the aviation system are similar to those used with other modes. The following can be included in indicators:

- Gross Regional Product or Gross State Product (total spending by consumers on goods and services produced within a specified region or state)
- Demand (value of all goods and services purchased within region)
- Employment (number of full-time and part-time employees in region)
- Output (value of all goods and services produced within region - not based on actually money spent)
- Personal income (total earnings from wages, passive enterprises, investment interest and dividends for individuals in a region).

2.8.3 Data Sources

The Federal Aviation Administration: *Estimating the Regional Economic Significance of Airports,* and the Bay Area Economic Forum (BAEF) have provided frameworks for conducting economic well-being analysis. The methodologies are well documented. The inputs to the economic impacts of investments and projects (e.g., number of jobs supported, revenue, etc.) are provided by individual airports.

2.8.4 Proof-of-Concept

The Bay Area Economic Forum: *Air Transport and the Bay Area Economy* was used for the proof-of-concept. BAEF measured the economic well-being of Oakland, San Jose, and San Francisco International airports to California's economic growth in four categories: employment, business revenue, personal income, and taxes. Results of the BAEF's research indicate that the economic well-being of airports in California can be determined.

2.8.5 Interpretation of Performance Measure

Monitoring the economic impact of airports allows decision makers to gauge the relative economic health of individual airports and the entire aviation system in relation to the overall economy of California. If a change in economic impact occurs, decision makers can investigate further to determine the causes of change. This in turn will help frame policy decisions. The economic well-being indicators could also be used for forecasting purposes (i.e., determining anticipated economic impacts of major aviation policy decisions).

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[10] *California Transportation Plan Transportation System Performance Measures Final Report, 1998*

2.8.6 Where Are We Headed Now?

Additional research is recommended to determine consistency in approach, and most appropriate applications for economic well-being.

3. CONCLUSION

Performance measures as defined in the System Measures Initiative and during the proof-of-concept testing for aviation are applicable for integration into planning processes. Results of the analysis of aviation-related performance measures presented in this report provide meaningful systemic performance information. Compiled on a regular basis, this information will aid planning and decision-making processes and add value to the state's roles in aviation (e.g., advisory, advocacy, regulatory, funding).

The proof-of-concept testing indicates that the proposed indicators can be successfully calculated. There is a recognition that the indicators developed would have different degrees of applicability to monitoring aviation system performance:

- The first set of indicators (i.e., for mobility/accessibility, reliability, safety/security, transportation system preservation, and environmental quality) are immediate applicable for monitoring at a system-wide level

- The second set of indicators (i.e., for cost effectiveness and economic well-being) are applicable but more suitable for use by airports directly or for forecasting.

Where appropriate, the indicators recommended in this report should be integrated into state, regional and local planning documents. Examples of these include the California System Aviation Plan (CASP) and future trends in California reports. Additional research is proposed to link aviation-related air emissions with regional air quality attainment status and emissions budgets. In addition, new research is recommended to explore ways that cost effectiveness can be applied to aviation strategies (region-wide or statewide).

The next few pages contain a "Quick Reference Guide" which outlines detailed findings, conclusions and recommendations for each outcome examined as part of this research.

Quick Reference Guide:
Detailed Findings, Conclusions, and Recommendations for Aviation

OUTCOME	INDICATOR	FINDINGS	CONCLUSIONS	RECOMMENDATIONS
Mobility / Accessibility	• Travel Time Delay: Difference between actual (gate-to-gate) travel time and scheduled travel time. • "Block Time" components of delay: – Gate – Taxi Out – Airborne – Taxi In	• Each delay component can be measured separately or as a "block" for individual Origin-Destination (O-D) pairs in California • Consolidated Operations and Delay Analysis System (CODAS - FAA) is the best data source • Block delay can be aggregated by airport	• This indicator is appropriate for measuring aviation system-related mobility • When measured over time, this indicator is useful for regional and state level advisory and advocacy	• Adopt proposed indicator and apply in two ways: – to the top 20 O-D pairs in California – to the top 10 airports • Include findings in future California trends reports • Add mobility performance measure to the CASP
Mobility / Accessibility	• Accessibility to airports: distance to airports (e.g. general aviation, small/ medium/large commercial, large commercial with trans-national service, international) • Accessibility to surface modes	• Accessibility to the aviation system (by airport type) can be measured via buffer analysis • Accessibility to desired surface transportation modes can also be tabulated by airport • Accessibility to desired destinations is problematic, due to poor data availability and a lack of consensus on desired destinations	• Accessibility to the aviation system can be modeled, however the travel time dimension requires additional investigation	• Adopt proposed indicators • Include findings in future California trends reports • Continue to explore ways to report on time-based travel • Add accessibility performance measure to the CASP
Reliability	• Travel time variability	• Airline Service Quality Performance (ASQP) is the preferred database that enables calculation of reliability for travel time • The ASQP database is available for purchase through the Bureau of Transportation Statistics (BTS) • Reliability data can be aggregated by O-D pair or by individual airport	• Reliability can be calculated and the ASQP is the best data source	• Purchase the ASQP from the BTS • Calculate reliability for the 20 O-D pairs and for the top 10 airports in California • Include findings in future California trends reports • Add reliability as performance measure to the CASP
Safety / Security	• Accident rate • Fatality accident rate • Non-fatal accident rate • Incident rate	• Accident rates can be calculated based on events divided by market VMT or by total operations • Data are available through National Transportation Safety Board website • The process is similar for commercial and general aviation	• Safety can be calculated and the NTSB is the best source	• Adopt indicator • Calculate safety performance measures for both commercial and general aviation • Include findings (both number of events and associated safety rates) in future California trends reports • Add safety as performance measure to CASP
Safety / Security	• Crime rates: events divided by Million Annual Passengers (MAP)	• Proof-of-concept testing was successful for category one and category two crimes (San Jose International Airport) • No central data source exists for security statistics statewide • To calculate the measure statewide, airports need to be contacted individually	• Security indicators are straightforward to calculate • Airports must be contacted individually	• Adopt indicator • Collect data for all commercial airports in California • Add security performance measure to CASP • Include security results in future California trends reports

OUTCOME	INDICATOR	FINDINGS	CONCLUSIONS	RECOMMENDATIONS
Cost Effectiveness	• Cost to benefit ratio	• The FAA provides general guidance on how to conduct a benefit-cost (BC) analysis for airports • Although several user benefits in the FAA guidance are unique to airports, they can be assigned to similar categories as the proof-of-concept testing for surface modes	• FAA framework is similar to the framework subject to proof-of-concept testing for surface modes • Cost-effectiveness is a valuable tool to assess aviation strategies	• Explore ways that cost-effectiveness can be applied to aviation strategies (region-wide or statewide) for potential inclusion in future California trends reports • Establish linkage with the CASP, i.e., encourage use of cost-effectiveness performance measure for project selection
Economic Well-Being	• GRP • Demand • Employment • Output • Personal Income	• Major commercial airports periodically examine their economic impacts • The FAA provides guidance on estimating regional economic impacts • As with other modes, regional models such as IMPLAN or REMI, can be used to calculate indicators	• Economic well-being can be measured for airports • Economic well-being is a valuable tool to understand the magnitude of regional or state economic impacts • Economic well-being is also valuable for modeling major changes to airports (e.g., BART to SFO)	• Calculate indicator for selected commercial airports • Consider inclusion in future California trends reports
Transportation System Preservation	• Asset condition • Cost to achieve desired condition • Preservation index	• Runways and taxiways are the main asset for which condition is systematically tracked by industry • The Airport Pavement Management System and MicroPaver software can be used	• Although there are many airport assets, pavement is the main one for which a condition can be determined	• Adopt indicators for aviation • Include in the State of the System Report
Environmental Quality	• Noise: Community Noise Equivalent Levels (CNEL) contours • Air: Airport-related air emissions	• Counties are responsible for monitoring and enforcing noise regulations • There are ten identified "noise problem" airports in California. Each monitors and reports on its own noise impacts • Caltrans receives quarterly updates • No agency monitors air emissions regularly. The agencies model air dispersion as well as DTEM for ground transportation • In the case of major expansion capital projects air emissions forecast are but no post-construction evaluations are conducted	• Environmental quality can be measured for noise • The impact of airports on air quality is difficult to determine due to the lack of a systematic approach to measurement and reporting of results	• Adopt indicator for noise • Include noise conformity status in the State of the System Report • Consider including airport air emissions in forecasting report • Establish linkage with CASP • Conduct additional research to link aviation-related air emissions to regional air quality attainment status and emissions budgets